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SAVONIA

HOW ADDITIVE TECHNOLOGY CAN BE USED IN SAVONIA'S EDUCATION DISCIPLINES

Thesis

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CONTENT

1 INTRODUCTION

The motivation of this thesis came from Anssi Suhonen, coordinator of this thesis and teacher in Savonia University, Kuopio.

This thesis takes a practical approach of the uses and applications of 3D printers in the different disciplines that offers Savonia University in Kuopio.

As an Erasmus student, I could see the differences between the two universities that I have been studying. In my home university, University of Zaragoza, we barely learn about additive manufacturing or 3D printing technologies.

However, teachers and students in Savonia University are using it regularly in order to do some research, learn about this technique and materialize some works. There are more than one 3D printer and they use different technologies, that shows the commitment of this university with this relatively new technology.

The use of 3D-printings is getting bigger constantly very fast. Lots of companies (like Ford, Boeing or Nike)[1] are already using this technology to do prototypes or parts of pieces, lots of researchers are using it in medicine[2] (entailing enormous advances in the field) and also there are lots of domestic use 3D printers.

First of all, the thesis will overview some general facts about 3D printing such as what is this technology about, its history, types of printers and some current applications.

After that, there are a chapter about how the 3D printers affect in the education.

Finally, the thesis talks about some real applications in the different Savonia's education disciplines in Kuopio.

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[1] Lyndsey Gilpin, «*3D printing: 10 companies using it in ground-breaking ways*» (26.03.2014), https://www.techrepublic.com/article/3d-printing-10-companies-using-it-in-ground-breaking-ways/

[2] Sarah Saunders, «*3D printing medical research*» (Several dates, several articles), https://3dprint.com/tag/3d-printing-medical-research/

2 3D PRINTING

Before start explaining the applications of 3D printers in the Savonia's disciplines, it is necessary to understand what 3D printing is, what are its current applications and it is also important to know several examples of how these technologies are used in education nowadays.

2.1 What is 3D-printing

3D printing, also known as **additive manufacturing** (AM), is a process in which the piece is created by adding successive layers of material until it is created. There are different ways of printing, it depends on what material is used or what technologies.

That is just the opposite of traditional fabrication methods, such as milling or turning, which are processes of machining technology, which means material removal.

The process starts creating a model with a Computer Aided Design (CAD) or with other systems such as a 3D scanner or a plain digital camera. Usually, the used format file is STL ("Standard Triangle Language").

2.2 History of 3D-printing

Unlike what people commonly think, 3D-printing is an almost 40 years old technology. It was in 1981, when Hideo Kodama of Nagoya Municipal Industrial Research Institute did a system of rapid-prototyping using polymers, the first time that additive manufacturing was developed. Three years later, in 1984, Charles Hull made 3D printing history when he created *stereolithography (STL)*, one of the most important and more used technologies these days.

From then on, additive manufacturing has been developed in several ways, giving rise to different technologies of 3D printing and different applications.

In the last 10 years, the progress of this technology has been highly important in several fields of knowledge and research, such as the medical field or prototyping applications. All these features in such a short time make experts and specialists think about all of its possibilities.

2.3 Types of 3D-printers

In this chapter, I will cite the different types of 3D printing technology that are currently being used which can be seen in the following diagrams, but only three are the most common: *Stereolithography* (SLA), *Fused Deposition Modelling* (FDM) and *Selective Laser Sintering* (SLS).

Most common 3D printing technology

Stereolithography (SLA)

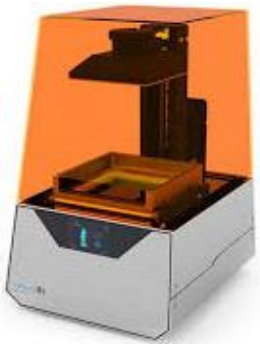
- The earliest AM technology in the history of 3D printing.
- **Materials used:** Plastics.
- **Applications**: Commonly used for fast prototyping processes.
- **Pros**: Good accuracy and precision.
- **Cons**: As this technology uses a point laser, the process can take longer than others.

Fused Deposition Modeling (FDM)

- The most popular type of 3D printing for individuals and small businesses.
- **Materials used:** Thermoplastics.
- **Applications:** Functional prototypes, concept models or ready-for-use products.
- **Pros:** Good details quality, strength-weight and cost-effective ratios.
- **Cons:** Depending on the geometry of the piece (overhanging parts more than 45° angle) sometimes is necessary to add support structures.

Selective Laser Sintering (SLS)

- **Materials used**: Nylon, glass, ceramics, some metals, etc.
- **Applications**: Commonly used to produce customized goods,
- **Pros**: SLS printing does not have to use some other support structure because the object is surrounded by unsintered powder.
- **Cons**: This technology requires high-powered lasers, which makes the printer rather expensive.



Other 3D printing technology

- Selective Laser Melting (SLM)
- Digital Light Processing (DLP)
- Laminated Object Manufacturing (LOM)
- Electronic Beam Melting (EBM)
- Binder Jetting (BJ)
- Material Jetting (MJ)

2.4 Currently 3D printing applications

Summarizing what has been said previously, we could say that 3D printing is a new tool, a new way of making pieces that can not be made without this technology or it would be more difficult. But that does not mean that it is going to replace other technologies, as machining process, it is going to complement them.

Nowadays, most pieces are still being made by material removal technologies or casting. Even so, **traditional technologies have some cons that additive manufacturing manages to avoid** such as geometric complexity, different porosities or materials in the same piece, flexibility with customization and with the change of the piece model, physical restrictions with the cutting tool and the piece itself, short production series. All of these characteristics are cons of traditional technologies but advantages of additive manufacturing, all of that without making the process more expensive.

Additive manufacturing is still a "new" technology, we can expect a lot from it because there are currently many different and useful applications.

The main actual applications of 3D printing can be catalogued in the different fields of applications, such as architectural, medical, mechanical, aeronautical or fashion, among others.

2.4.1 Applications in architectural fields

Although architectural applications of 3D printing are not one of the most important nor transcendental, they are very useful.

Most architects must make **models** in order to show the investor or the boss what he/she has in mind. 3D printing is an excellent tool to materialize ideas and make escalated models of the building or construction that it is being studied.

The same with the architecture students, over the years studying architecture they must make many models that, with this technology, could be easier, faster and they would end their studies knowing how 3D printing works, so they would be able to use it in the future.

2.4.2 Applications in medical fields

3D-printings has become a revolution in medicine, a new way to do things that were impossible in the past, and a new tool that involves an impressive future. Is in this field where we can see the further progress of this technology.

Some applications are:

- **Prosthesis and orthosis.** This new technology has involved an enormous evolution in this field. That is because it allows to make the perfect prosthesis or orthosis depending on the patient needs.
- **Modeling.** By the use of 3D-printing, experts can make exact replicas of organs or other parts of the human body, so the doctors have a real-scale model of the area that they are going to operate. This allows them to do the practices and simulations, which reduces the time of surgery. Using a 3D scan they can detect malformations in the organs and also print the fetus from ultrasounds, so they can detect a potential malformation, as well as allowing blind people to touch it.
- **Artificial tissue.** Through the use of 3D-printers, scientists have produced artificial tissues with similar properties to humans. This has been used in reconstructive surgeries of patients who have suffered accidents or burns.

All of these applications, among others, are quite advanced in the hospitals and research laboratories, but there are others that are still in investigation stage. One

example of that is bio-printing, what means the printing of living organs. The idea of doctors and scientist is to be able to generate organs for transplants with 3D printers.

2.4.3 Applications in mechanical fields

Additive manufacturing allows to create **mechanical pieces with complex shapes** that are very difficult or even impossible to create them with traditional technologies. So, it minimizes the number of steps in the assemblies and welding, that results in saving time. Due to this characteristic and the others mentioned before, 3D printing is commonly used to do **prototypes** (rapid prototyping, what shorten the product development time from few months to a few days), **pieces on demand** or different parts and pieces as long as AM provides the appropriate properties.

2.4.4 Applications in aeronautical fields

Similar to the applications in the mechanical fields, in the aeronautic fields AM is used to create **prototypes** that need to test in wind tunnels. That is because the aeronautic and aerospace industries need to be very precise with the geometric, making complex surfaces, what makes 3D printing an excellent technology to do that.

2.4.5 Applications in design or marketing

In this case, 3D printers can be used like in architecture. It is very important to have a escalated **model** of the product to show to the boss or investor.

2.4.6 Applications in other fields

Nowadays, 3D printers are quite cheap, is that the reason of why so many people have it in their own home and why there are lots of different websites full of models of pieces do it by yourself. Some of these pieces are gasses, drones, cameras or several decorative pieces.

In the textile industry and even in the food industry, 3D printers have also become to be used the last years.

3 3D PRINTING IN EDUCATION

Gradually, 3D printers are becoming more useful in classrooms and labs around the whole world. There are teachers and educators who have already integrated this technology into their lessons.

Using 3D printing in education has lots of benefits however, it is not commonly used. That is because the teachers do not have the required training to know how to use these printers and how it works. Once the schools, highschools, universities or other educative center wants to use it the only thing that they must do is to provide the necessary formation. Because the invest that they will need, and the maintenance cost are very low compared to the educational benefits.

Down below, I will write the main factors that make AM an excellent and useful tool in education, and also a necessity to integrate this new technology into the curricular development of the students:

- **Supports and develops the creativity and the ability to resolve problems**. This is maybe the most important reason. With 3D printing the students can materialize ideas in real objects. This fact is what cause a change of mentality in the students because they must use their knowledge, imagination and creativity in order to resolve the problem. Creativity will be increasingly demanded and, as in the future lots of companies or jobs are going to use 3D printers, it would be good if the students know how to use it.
- **Increase the participation of students and capture their interest**. The experience of print in that technology is something new that most of the students have never done, so they will want to experiment, create or design some pieces. It also allows the students to see their own results of their work and they will be more motivated. It is an added value to education that can make the difference.
- **Facilitate the teacher's task**. As it has already been said, the fact that the teacher could give to the students a three-dimensional prism, hearth with malformations or a ball bearing printed by a 3D printer instead of showing it in a Power point it is full of benefits.

It is true that these factors make the 3D printers very useful in the education but is maybe in primary and secondary education where can be used almost in every subject and where the kids are more interested and fascinated about this technology.

In the **first years of education (until 12 years old)**, 3D printed models will make students see how it is the skeletal system, the different organs, geometric bodies, or animals among other applications. All of these applications will be helpful for visually impaired students, as research from the Korea Institute of Science and Technology revealed. [3]

After that, in **secondary education (12 – 18 years old)**, it would be similar to primary education. Students could see models of topographic maps, some recreations of historical constructions or tools, atoms, etc. 3D printers would start to be familiar to the students, so they will consider this technology in the future.

However, in **higher education (from 18 years old)** 3D printers would have real applications, not only to show the students pieces but also, they would be able to do their own works, pieces and prototypes. Students of technological fields will learn skills that are in demand nevertheless, 3D printing has applications from science to art.

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[3] Kira, «*3D printed teaching aids enhance education for visually impaired students*» (05.05.2016), http://www.3ders.org/articles/20160605-3d-printed-teaching-aids-enhance-education-for-visually-impaired-students.html

4 APPLICATIONS OF 3D PRINTING IN THE UNIVERSITY OF SAVONIA

As has already been said, 3D printers have very good advantages that gives students not only but useful knowledges and experience that they could use in their professional future. The lack of 3D printers and teachers who know how this technology works is probably the reason that 3D printing is not used as much as it should in universities. But gradually that is going to change. However, Savonia University (Opistotie campus) has more that one kind of 3D printers and also teachers who knows exactly how it works. The engineering students are learning the basics of this technology in their first years of the studies.

Once you have the tool, applications must be searched. This is what this chapter is about.

4.1 Savonia disciplines

Savonia University offers a versatile Degree Programmes along different campuses which are located in three cities: Kuopio, Iisalmi and Varkaus.

The campuses are: *Opistotie Campus* (Engineering, Technology and Design), *Microkatu Campus* (Health, Tourism and hospitality, Business and administration, Engineering), *School of Music and Dance*, *Iisalmi Camp* and *Varkaus Campus*.

4.1.1 Engineering

Engineering studies takes place in Opistotie Campus, Kuopio. There are two main alternatives: Polytechnic engineers and the Building Master (specialist in building construction)

Engineering is one of the disciplines which would be more benefited if 3D printers and additive manufacturing were introduced in education. Not only because of the applications, but also because it is a field of engineering that is on the rise. 3D printers can produce objects with more complex structures that traditional manufacturing methods.

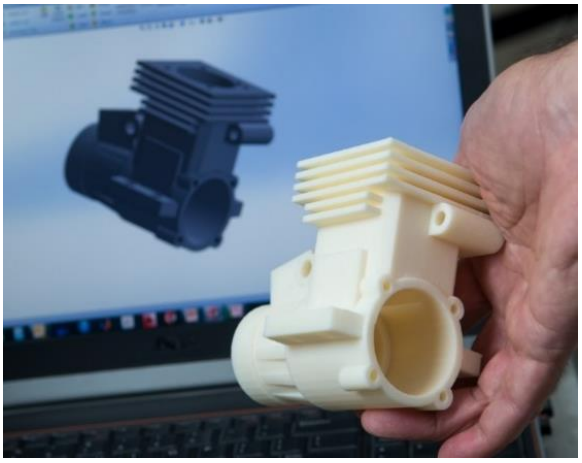
Savonia University has done a good research job implementing this technology into the lectures and in the laboratory exercises of the students.

As a mechanical engineering student, I think that is important to know the different types of additive manufacturing and when to use it, which material and how to design in order to print the piece in question. In that sense, Savonia University (Opistotie campus) is ready to afford that matter since it has several types of 3D printers depending on the piece, application or material.

First of all, as 3D printers are being increasingly important in engineering, the best option to understand how it works is having one. So, the first application would be to **learn the mechanics, fundaments, applications and limitations of this technology**. Just like it is done with traditional technologies such as milling or turning.

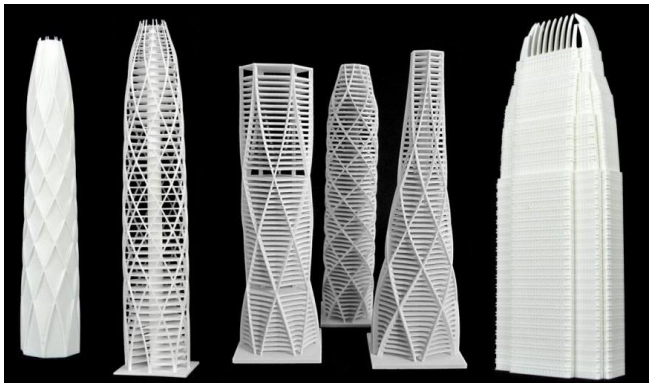
This application is already being done in Mechanical Engineering at Savonia University.

Other application is **printing pieces or mechanisms to show to the students**, so they can understand quickly how it works seeing and touching it. In the following images there are some objects that can be created by 3D-printers:



PICTURE 1. 3D printed two-stroke model engine block (Photo, model and printed by Northern Essex Community College Engineering professor Jim Calahay)

PICTURE 2. 3D printed Jet Engine.



PICTURE 3. Models of buildings printed by a 3D printer.

As has been said before, materializing some ideas and pieces would suppose a really good change in student's mentality. We will see that this application would be even more important in other disciplines of Savonia University, as the medical one.

One last application of this technology is the fact that the students could **materialize pieces** and parts of machines as the final part of a work.

At this point in time, knowing how to do a design in a CAD (Computer Aided Design), CAM (Computer Aided Manufacturing) or/and CAE (Computer Aided Engineering) software. Along the years of study, the students will know how to use these programs, and this is an indispensable part in the process of 3D printing. Probably in the third year of the different engineering degrees.

One way to work with this technology could be to design a part of a machine that must be repaired, do it in a software which can save the file in STL (Standard Triangle Software) format and then print it after choosing the appropriate parameters. With this application students must be creative because they have to use their knowledges about design softwar and machines in order to identify the piece or part that is not working and materialize it. Other option could be to make this piece lighter.

An alternative of this application could be doing the design of a piece that other discipline need to use, or maybe only to print it. That would communicate different departments in a situation that everyone wins. The engineering student will know how to use the printer and the teacher will have the object that needs in order to show to his/her students or if it is another student, he/she will be able to materialize his/her work (in other disciplines I will talk about that again).

4.1.2 Design

Savonia offers the design degree program in the Opistotie campus. This degree has different orientations or applications: Interior designer and furniture designer, jewelry designer, industrial designer, or clothing designer. The goal of these studies is to make students able to develop and design products, environments and services.

The applications in **Industrial design** discipline would be quite similar to the engineering ones.

During the years of study, design students will learn how to design pieces or objects using CAD software in which they can save the file as STL format. So, 3D printing can be very useful in this field since students are required to do several designs in their studies.

3D printers have the ability to print **functional prototypes** of the product then, the product designers can verify that the object have the required specific characteristics. After discussing between the students, they can do some changes if the product needs it or even redesign it completely without a significant loss of time nor money. That makes the process more efficient.

According to James Antifaev, co-founder and CEO of *Made for Me* (global platform for designers to discover and source prototyping services using 3D printing) in the "IDSA's International Conference: Making Things Happen" of 2016:

- 51 percent of designers use 3D printing in at least 60 percent of their projects
- 2/3 of designers utilize an in-house 3D printer
- 63 percent of designers outsource some or all of their 3D printing

Antifaev adds in the report: *"New manufacturing technologies are making the production of models and prototypes more accessible than ever before"* and *"While additive manufacturing (commonly known as 3D printing) has been around since the 1980s, the last few years have seen an accelerating proliferation of technologies, services and business models that give designers greater choice than ever before."* [4]

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[4] Unknown, *«3D printing in Industrial Design»* (09.02.2018), http://www.idsa.org/news/design-news/3d-printing-industrial-design

Summing up, 3D printers are a new technology which has experienced a great increase of its use and applications. At the present time, a significant number of designers have their own printer that thy use for their projects and models and products. But also, the companies use this technology in design, according to Steinar Killi, doctoral candidate at The Oslo School of Architecture and Design: *"Major brands such as Nike, Nokia, and Ittala have already started to deliver products that are manufactured and designed using 3D printing."* [5]

This is probably the best reason to use 3D printers in design studies. Students can use it to materialize their models and products, but they will probably use additive manufacturing in their jobs, so I think that it is extremely important to teach the students how to use this tool.

In **Jewelry design** 3D printers can be extremely useful due the possibility of making **models** that are impossible without this technology. The production of jewelry with 3D printers can be done via investment casting and direct printing (much less popular, more difficult and expensive).

PICTURE 4. Jewelry produced by investment casting with 3D printed models.

[5] Trude Løw Hansen, *«3D printing will revolutionize the design profession»* (06.06.2013), http://sciencenordic.com/3d-printing-will-revolutionize-design-profession

There are also some interesting applications in **Interior and furniture design** due to the huge possibilities of 3D printers, as shown in the following images:

PICTURE 5. 3D printed design by DXV.

PICTURE 6. Art sculpture lamp made by polyamide nylon 3D impression.

While in **Clothing design** 3D printers are also useful, but not as much as other fields. However, 3D printers allow to create designs almost without limits, so there are some applications. Students must use their creativity to make different models which fit in the corresponding clothes.

4.1.3 Business

Business degree program, offered in Microkatu campus, affords the students to learn business professional skills that are needed in all industries, business and communities. The alternatives of this degree are: Business developer, sales and marketing, financial management and entrepreneurship.

Business is one discipline that does not have so many utilities as engineering and design fields. The main difference is that in this course they do not learn how to use any CAD software and they do not usually work with products. So, it is difficult to find applications of 3D printer in business field.

As has been said before, there are a lot of big companies and brands that are currently using 3D printers in their marketing section. One application that can be useful would be to **raise issues related to 3D printers** to the students, so they must decide between buy 3D printers or other technologies.

This is a forced application, but students will know that this technology is very important and that it will be even more important in the future of different fields, including product marketing.

Other application can be seen in **product marketing**, the process of selling and promoting a product to a customer, combined with design or engineer students.

In that case, business students do a project in which they must develop a product using all the knowledge and collecting customers information doing interviews. After all the research, they must take the appropriate decisions and send their conclusions to the design or engineering students, who will do the design of the product and will share it with business students. When an agreement is reached, the product will be printed.

This application could be done since students knows how to do some research and know how the market works, from the second year that application makes sense.

With this method, students will learn:

- To cooperate with other people who works in different fields, understanding how other labors works.
- To do their tasks on time not because the teacher has settle a deadline, but because other people depend on them.
- To understand the workflow of a product.
- To give the best of themselves because it is not a one-man job.
- Deal with some situations and behaviors of people that happen in reality.

All of these aspects of this method of work can be seen in real life. It will prepare them for their professional future.

The applications of 3D printing are not directly related to business but with that students could learn very important and useful lessons that will help them in the future.

4.1.4 Social services and health care

Students are graduated in healthcare professions from a variety of training courses, including bioanalytic, emergency care, physiotherapy, nursing radiography and radiotherapy, social care, oral health care and social and health care management and development.

3D printing has a hopeful future in the medical field. As has already been said in the section *2.4.2 Applications in medical fields*, there are already some useful applications that have generated very important improvement in the field although they have been recently implemented. It is an excellent tool for the acceleration and improvement of medical training. Because of that, it is logical that students should finish their studies knowing the existence of this technology, its capabilities and its potential.

To make this happen, there are several applications of 3D printers in this field that should be applied.

The first of all would be to produce **anatomical replicas** of organs (or some parts, like a heart valve), muscles, bones or some anatomical systems such as digestive or respiratory systems.

With this application, teachers would teach more effectively, so students will learn faster and better.

PICTURE 7. 3D printed anatomical models by 3DyourSCAN, WhiteClouds.

Jerry Ropelato, CEO of WhiteClouds, said: "*3DyourSCAN will help doctors better visualize complex clinical scenarios and improve collaboration among physicians and patients* [6]*,* referring a service to provide surgeon with 3D printed life-size colour anatomical models based on patient's scans (3DyourSCAN)

This is an example of professional models for special situations, but it shows that this kind of models are very useful.

As AM is regularly used to produce low-cost **prosthetics** or components of prosthetics which match perfectly with the patient, showing some examples to students would be a good way of learning.

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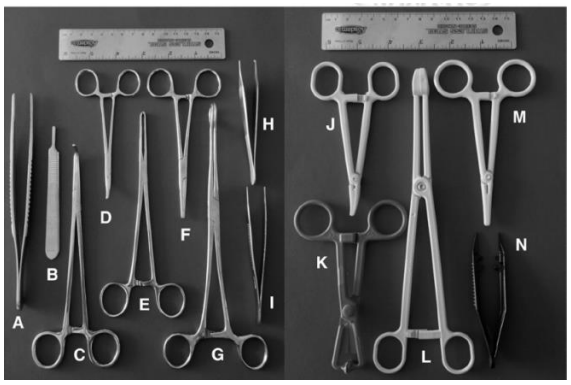
[6] Doris, «*3DyourSCAN Service by WhiteClouds Provides Surgeon with 3D Printed Anatomical Models*» (17.11.2016), https://www.3printr.com/3dyourscan-service-whiteclouds-provides-surgeon-3d-printed-anatomical-models-2844199/

Other application is **training medical procedures using 3D printed simulators**. 3D printers allow to create multi-material models which can replicate with good precision the complexity of human body.

Printing **medical equipment** would be another application. A good way to cooperate with other departments like engineering or design. One example of that is the organization iLab//Haiti, which brought 3D printers in 2013 to Haiti to teach them how to use it. They began doing some simple medical tools like the following umbilical cord clamp.[7] Other example is the medical tools (such as scalpels, scissors or forceps) that were printed in a 3D printer in order to bring it to do surgeries in the International Space Station due to its weight.[8]

PICTURE 8. 3D printed umbilical cord clamp.



PICTURE 9. 3D printed medical tools for the space.

The last application is one that is already being used. 3D printers allow to make **pills or tablets**. That is a great advantage to people who have to take more than one pill per day, instead of that, they could take only one produced by a 3D printer. Students can make personalized pills for real patients as part of a work.

Pills can be also printed with different forms or shapes that kids like depending on their interests and hobbies.

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[7] Michael Molitch-Hou, «*3D printing recover with iLab//Haiti*» (28.10.2013), http://3dprintingindustry.com/news/3d-printing-recovers-ilabhaiti-19205/

[8] Hanna Rose Mendoza, «*Researches study the 3D printing of surgical instruments for use in long space missions*» (17.07.2014), https://3dprint.com/8937/3d-printing-space-missions/

Unfortunately, some of these applications have disadvantages such as cost, availability, the materials needed, and obtaining the CAD designs is probably difficult or expensive. Nevertheless, the benefits of this technology are worth it.

4.1.5 Music and dance

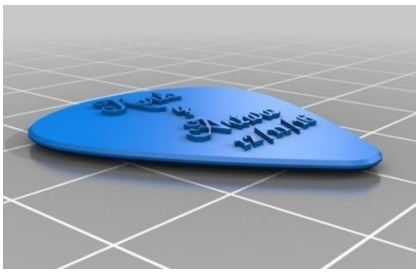
Music and dance studies take place in the Music Center of Kuopio, among other places. These studies provide advanced degree-level education for teachers of music and dance, music pedagogues.

Is maybe in this discipline along with Business in which the applications are more limited, and it is difficult to imagine uses of this technology in this field. Even so, there are several applications that can boost the interest and creativity of students. These applications prove the huge utility and versality of 3D printing.

Although additive manufacturing has limits, like every other technology, it is probably the human creativity and ability to find new applications the most important limiting factor.

In Savonia's school of music and dance, students improve their skills in music, playing instruments and dancing.

One application of 3D-printing in **music school** could be making the **customized guitar and bass guitar picks**. As a guitarist I know that is common to lose the picks so, if some engineering or design students produce picks in order to see how the machine works, the music students could use them.

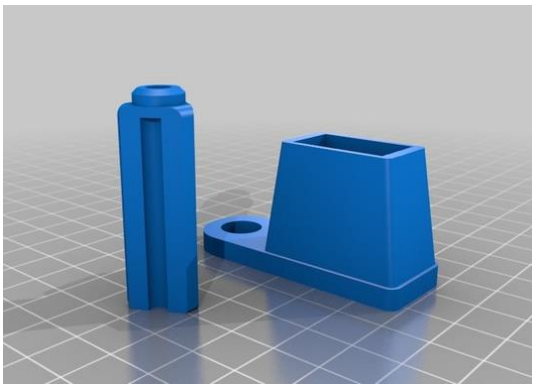


PICTURE 10. Guitar pick model.

PICTURE 11. Guitar picks printed by 3D-printer.

Students and teachers must practice every day with their instrument and it is mandatory to be tuned. So, tuning can be an inconvenience If they must do it several times per day another application could be making **string winders**, used to make easier the action of tuning the instrument.

PICTURE 12. String winder.



PICTURE 13. String winder model.

Other application that could save lot of money to the instruments owners is to produce the **mouthpieces** of some wind instruments such as flutes, saxophones, trumpets or trombones. Some of these mouthpieces are expensive but with this technology and with a good model that could change.

PICTURE 14. Saxophon mouthpiece.

PICTURE 15. Trumpet mouthpieces.

While, in **dance school** 3D printers could be used not for the learning, because they hardly need any material but their own bodies, but for the staging.

3D printing could be used to produce **props or theatrical property**. In that sense, the only limits will be the ability of the designer and the imagination of the teachers and students in order to choose what do they want to decorate the dance play.

4.1.6 Tourism and catering

These studies can be studied in Microkatu Campus, Kuopio. Savonia offers the Restonomi degree in tourism and catering.

Although this technology is quite new in this field, there are currently several restaurants that use 3D food printers such as *Mélisse Restaurant* in Santa Monica (EEUU), *La Enoteca at Hotel Arts* in Barcelona (Spain), Food Ink in London (UK) or *La Boscana* in Bellvís (Spain)[9]. So, one application could be introducing students to 3D printing of food.

To make this happen, they would need some **food 3D printers**, which are not the same as the SLA or FDM. According to Hervé Malivert, director of food technology and culinary coordinator at the International Culinary Center: *"With a 3D printer you can print complicated chocolate sculptures and beautiful pieces for decoration on a wedding cake"* [10]. This will allow the students to be more creative with the food presentation experimenting with shapes and even flavors.

However, printing food with a 3D printer is more complicated that printing plastic or metals and probably is this why 3D food printers are not as common as regular 3D printers yet. So, this application would be quite difficult to introduce.

The next application is based on Dinara Kasko, an architect turned into a pastry chef who uses her knowledges in CAD modeling to make **models** which she prints in a 3D printer and then, she uses those molds for her cakes.[11] That is an extraordinary example of what a design and a catering student can do together.

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[9] Rawal Ajmed, *«4 famous restaurants that use 3D printers»* (24.03.2017), https://3dprinting.com/food/4-famous-restaurants-that-use-3d-printers/

[10] *Kyle Wiggers, «From pixels top late, food has become 3D printing's Delicious new frontier» (19.04.2017),* https://www.digitaltrends.com/cool-tech/3d-food-printers-how-they-could-change-what-you-eat/

[11] Claudia Romero, *«A Ukranian pastry chef is making geometric desserts using a 3D printer»* (20.10.2017), http://www.businessinsider.com/ukrainian-pastry-chef-makes-geometric-desserts-using-a-3d-printer-2017-10?r=UK&IR=T&IR=T

PICTURE 16. Process of modeling by Dinara Kasko.

PICTURES 17 AND 18. Dinara Kasko's pastries using 3D printed molds.

Other option could be **producing decorative pieces or objects** in order to improve the food presentation.

5 CONCLUSIONS

3D printing is a technology which is revolutionizing several fields and contributing to expand new solutions and different approaches to solutions. We will see how far it goes and what new applications it can offer us, but it seems that a great future awaits due to its great benefits.

In my opinion, 3D printing can promote the learning in every stage of education. Making easier the understanding and interest in the lectures and subjects.

Several companies are already using this technology, so it would be perfect if the students start to think about this technology when they have to solve a problem or do some work. Making students know the applications of this technology would be a change in our way of thinking and designing products.

As I see it, this new sight in students is the most important reason to implement additive manufacturing in education.

In this thesis several applications have been shown, one more useful than others.

Medical, Design and Engineering applications, for example, are an excellent example of what a 3d printer can do. They will need the knowledge of this technology in the future, so I think that in these fields 3d printing must be implemented.

In Business or Tourism and Catering fields the applications are not really useful. It is not completely necessary to introduce this technology. They will not need that to their future. However, 3D printing is more creative than traditional technologies and offers new levels of design, so it can be applied in those fields if you are creative and you know how this technology works.

Summing up, Savonia University have the tool that only the students will know how to apply it in their own professional lives. If all of them know how it works, there is a chance that they will find some creative and innovating applications of this amazing technology.

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